ATARI® PROGRAM EXCHANGE

Thomas C. O'Brien

TEASERS BY TOBBS

Tell Tobbs how to solve math problems in a puzzle grid

Diskette: 16K
(APX-20201)
Version 1

Edition A

User-Written Software for ATARI Home Computers

TEASERS BY TOBBS

by Thomas C. O'Brien

Distributed By

The ATARI Program Exchange
P.O. Box 3705
Santa Clara, CA 95055

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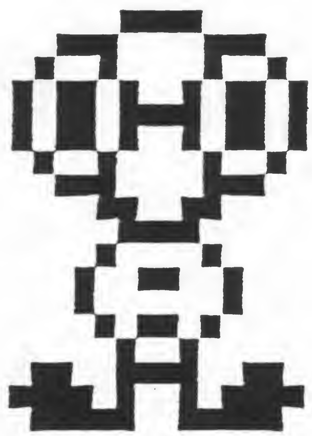

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Introduction

Overview

Teasers are puzzle grids of nine squares, three squares across by three squares down. A symbol for addition (+) or multiplication (x) appears in the top left box. The numbers across the top row are multiplied by, or added to, the numbers down the left column to give sums or products in the inner boxes. Some of the numbers are missing, and it's up to you to fill them in. Tobbs hops into an empty square and you type a number to fill it in and help him complete a grid.

The puzzles offer math drills in addition and multiplication--and much more. You have a choice of six difficulty levels, ranging from adding and multiplying one-digit numbers to more complicated problems. At the higher levels, problems contain two-digit numbers, and they require you to work backwards from the sum to the addends or the product to the factors. At the sixth level, there might be more than one possible answer for some of the squares. The puzzles teach more than number facts; they encourage creativity in problem solving, and they tackle the difficult concept of "reversibility." This term means that you can work in one direction to find answers, and in the other direction from answers to questions. (Reversibility is a critical skill for intellectual progress, but educators know that it's hard to teach.)

Tobbs gives you hints, instructions, and help whenever you press a key. He shakes his head firmly when you're wrong, but he shows his delight when you're right.

One to four players can use the game, and teams can challenge each other. Teachers can use the program in the classroom, but parents can also help children improve their skills at home. Adults are challenged by the higher levels, too!

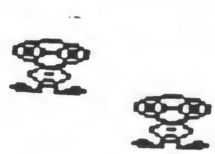
Required Accessories

16K RAM
ATARI 810 Disk Drive
ATARI BASIC Language Cartridge

Contacting the author

Users wishing to contact the author may telephone him at:

800/431-1934



Staff

Editor: Marge Kosel

Programmers: Cathy McMahon, Jay Carlson, Todd Bailey, and Jim Brayton

Acknowledgments

Many people helped to get this work to its present state and I am pleased to say "thank you" to them.

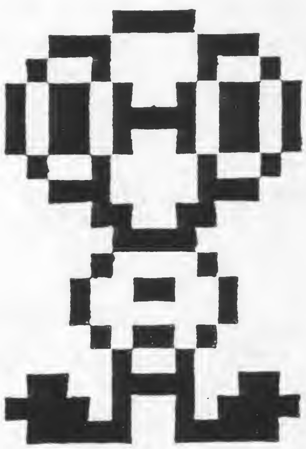
Thomas C. O'Brien III taught me that a computer is not full of dragons. Liza Loop helped to get this project from a mere idea to a pilot product. Bill Maintz contributed great good will, encouragement, and thoughtful advice. Jeff Van Arsdale taught me not to do stupid things at the keyboard. Many local teachers--especially Z. Miller, Mary Steffen, and Shirley Casey--and their school children helped greatly with informed and constructive criticism.

Marge Kosel and Cathy McMahon brought great insight, care, and expertise to the final product.

And my family gave patient support from dog days to triumphant tryouts as the present work grew in maturity and complexity.

To all of you, my warmest thanks.

Thomas C. O'Brien



Getting started

Loading TEASERS BY TOBBS into computer memory

1. Insert the ATARI BASIC Language Cartridge in the cartridge slot of your computer.

2. Have your computer turned OFF.

3. Turn on your disk drive.

4. When the BUSY light goes out, open the disk drive door and insert the TEASERS BY TOBBS diskette with the label in the lower right-hand corner nearest to you. Close the door. (Use disk drive one if you have more than one drive.)

5. Turn on your computer and your TV set. The program will load into computer memory and start automatically.

The first display screen

When the program has finished loading into computer memory, the following information displays on the screen beneath a sunburst design:

SUNBURST
COMMUNICATIONS
Copyright 1983

Playing TEASERS BY TOBBS

The menu

The menu appears immediately after the first display screen. You have the following choices:

```
 -------------------------------
|     1) ADDITION               |
|     2) MULTIPLICATION         |
|                               |
|     3) Descriptions           |
|     4) End                    |
|_______________________________|
         Which number?
```

Type the number of your choice and press the RETURN key. For example, type 1 to select ADDITION teasers.

When you choose 3) Descriptions, you see a short written explanation of what to expect if you select addition or multiplication. Then you return to the menu to choose another option.

If you choose 4) End, the program asks if you'd like to use another diskette. If you'd like to continue using the computer for another program besides TEASERS BY TOBBS, type "YES" (or just "Y") and press the RETURN key. Then remove the TEASERS BY TOBBS diskette and insert the other diskette. If you don't want to use another program, and you're finished with TEASERS BY TOBBS, type "NO" (or just "N") and press the RETURN key. The program gives you instructions to remove the diskette and turn off your computer system.

Instructions

As soon as you select addition or multiplication from the first display screen, Tobbs introduces himself. Press the RETURN key after you've met, and he asks if you'd like instructions. If you want to go straight to the teasers without instructions, type "NO" or "N" and press the RETURN key. If you'd like Tobbs to instruct you in how to solve the problems, type "YES" or "Y" and press the RETURN key.

He explains in detail how the puzzle grids work. After each screen, he reminds you to press the RETURN key. Sometimes he asks you for a number. After you type it, remember to press the RETURN key. A list of the game rules concludes the instructions.

Sample puzzle grids

Here's what typical puzzle grids look like. These examples are from the lowest difficulty levels of addition and multiplication:

+	8	5
4	12	
0	8	5

Figure 1

X	1	4
2	2	8
3	3	

Figure 2

Tobbs asks you what number to put in the box he's in. The sums and products are placed where straight lines drawn down from the top row, and right from the left column, would meet. For example, in Figure 2, Tobbs is looking for a 7, because you could draw a line down from the 4 and across from the 3 to the box he's in.

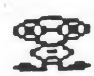
Number of players

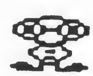
After going through the instructions, or selecting addition or multiplication from the menu, you must tell Tobbs how many people or teams are playing. You may choose a one-, two-, three-, or four-player game. You can play alone, against other individuals, or in teams. Whatever you choose, type in the name of the player or players, or the teams (up to 8 letters each) and press the RETURN key after each name.

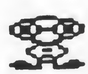
When the puzzles begin, Tobbs always asks a specific person or team to answer.

Limits

The program accepts only whole numbers from 0 through 99. It rejects negative numbers (e.g., -2), decimals (e.g., 1.5), fractions (e.g., 1/5), or three-digit numbers (e.g., 105).







Difficulty levels

TEASERS BY TOBBS has six levels of difficulty each for addition and multiplication problems. Level 1 is the easiest and level 6 is the hardest. Each level builds on the previous one, adding some new skill. Therefore, before you begin to work on level 4, for example, you should be able to do level 3 comfortably. The following descriptions show what you can expect at each level.

"Outside" numbers means those across the top and down the left side. For example, in Figure 3 below, 8, 5, 4, and 0 are outside numbers. Outside numbers are added or multiplied together to give you the sums or products. These sums or products are called "inside" numbers. In Figure 3 below, 12, 8, and 5 are inside numbers.

The addition problems challenge your logic as well as addition skills on grade levels three through twelve. The multiplication problems require skills on the fourth through twelfth grade levels. The reading level for all the problems is third grade, according to the Spache measurement. Although there's no time limit for the problems, each teaser should take one or two minutes to complete.

Addition, Level 1

In these addition problems with addends from 0 to 9, only one inside unknown number is missing. Here are some Level 1 puzzles:

+	8	5
4	12	
0	8	5

Figure 3

+	6	5
5	11	10
9	15	

Figure 4

In Figure 3, the 4 and the 8 add up to 12. The 0 and the 8 add up to 8. The 0 and the 5 add up to 5. What about the 4 and the 5? The correct answer is 9. Can you solve the puzzle in Figure 4?

Level 2

Level 2 is the same as level 1, except that there are as many as four inside unknown answers. Some examples follow. In these examples, two inside numbers are unknown.

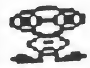
+	8	7
9	17	
6	14	

Figure 5

+	8	3
5		8
8	16	

Figure 6

Answer Tobbs's question in Figure 5 by adding the 7 from the top to the 9 on the left. You'd put a 16 in the square he's in.

What's the answer to Tobbs's question in Figure 6? It's 13.

Level 3

This level is like Level 2 except that the addends range from 0 to 48. You might want to use pencil and paper to reach an answer, but you might come up with your own addition procedures like "39 + 20 is 59 because 40 + 20 is 60 and 39 is 1 less than 40". Here are some grids from Level 3:

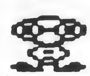
+	37	20
21		
39		

Figure 7

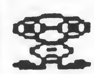
+	35	7
21		
39		

Figure 8

Level 4

This level is the same as level 3, except that these puzzles sometimes make you work backwards, from the sums to the addends. Look over the following example:

+	4	7
3	7	10
	5	8

Figure 9

The question is "What do you add to 4 to get 5?" (Or "What do you add to 7 to get 8?")

Also in level 4, you have to decide where to begin working on a puzzle. You might not be able to go straight to the box Tobbs is asking for. Sometimes you have to work backwards (that is, solve other problems before you can determine the number Tobbs is asking for). Look over the following example:

+		
5	7	
9		10

Figure 10a

It looks at first as if there's no answer! "I add 5 to something to get something." But there's more information in the grid. Looking at the bottom row, you can see that 9 + something is 10, so you can mentally put a 1 in the upper right box. Now you can say "I add 5 to 1 to get 6".

+	(2)	(1)
5	7	
9	(11)	10

Figure 10b

In Level 4, the outside numbers range from 0 to 9. Therefore, the inside numbers must range from 0 to 18.

Level 5

These grids are the same as the ones in Level 4, except that the outside numbers range from 0 to 49. Here's a typical Level 5 puzzle and its solution:

+		
3	5	
17		42

Figure 11a

"17 plus something is something. I don't know what to do. I do know what to add to 3 to get 5."

+	(2)	
3	5	
17		42

Figure 11b

So the original problem was really 17 + 2.

+	(2)	
3	5	
17	19	42

Figure 11c

Now you can complete the entire grid!

Level 6

This level is different from all the others. The range of outside numbers is 0 to 49, as in Level 5, but for the first time you have a choice, within limits, in answering some of the puzzles. For example:

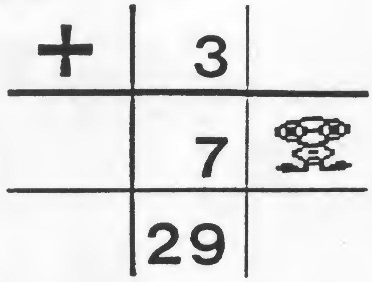


Figure 12a

You can find the left outside numbers easily enough:

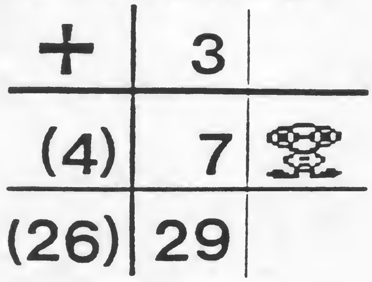


Figure 12b

But that's no help at all in finding the box Tobbs is asking you for. The solution is that the box can be 7 or 35 or 50 or <u>any number</u>, so long as the puzzle doesn't go beyond its limit of whole numbers from 0 to 99. Try 40:

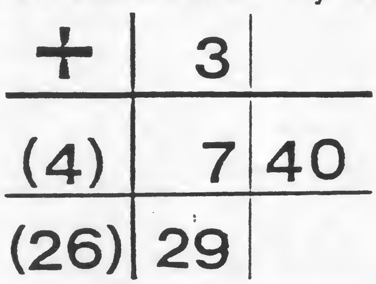


Figure 12c

Right! Now you can fill in all the open boxes. Here's the full solution if you use 40:

+	3	36
4	7	40
26	29	62

Figure 12d

Of course, you didn't have to choose 40 for the original puzzle. Here's another example:

+	3	
	7	
	29	

Figure 12e

Suppose you'd chosen 2:

+	3	
	7	2
	29	

Figure 12f

This would force the system beyond whole numbers from 0 to 99 because you have to add −2 to 4 to get 2 in the middle right box:

+	3	−2
4	7	2
26	29	

Figure 12g

Oops! Would anything from 4 to 99 have been OK? Here's 97:

+	3	
	7	97
	29	

Figure 12h

+	3	93
4	7	97
26	29	119

Figure 12i

Oops! Ninety-seven wouldn't have been correct, because it forces you to use a number beyond the 0 to 99 range (119). The solution to the original problem is any whole number from 4 to 77. Here's what happens if you choose 77:

+	3	73
4	7	77
26	29	99

Figure 12j

Multiplication, Level 1

Level 1 offers drill and practice with factors from 0 to 4, withe inside unknown. Here are some examples:

X	2	1
4	8	
0	0	0

Figure 13

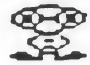
X	1	4
2	2	8
3	3	

Figure 14

Level 2

Level 2 is the same as Level 1, except that up to four inside unkn appear. Here are some Level 2 grids:

X	1	0
4	4	
1		

Figure 15

X	3	2
4		
2		

Figure 16

Level 3

Level 3 is the same as Level 2, but this time the factors range froıas in the following grids:

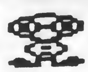
X	7	5
1		5
8		

Figure 17

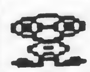
X	3	2
5		
0		

Figure 18

Level 4

Level 4 is the same as level 3, except that these puzzles sometimes make you work backwards from the products to the factors. Consider the following example:

X	4	1
3	12	3
	8	2

Figure 19

The question is "What do I multiply by 4 to get 8?" (or "What do I multiply by 1 to get 2?")

Also in Level 4, you have to decide where to begin working on a puzzle. Sometimes you have to work through several steps to get the answer. Here's an example of a Level 4 puzzle:

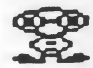
X		
4	8	
3		9

Figure 20a

At first, it seems as if there's no answer. But there's always more information lying around. Figuring that 3 times something is 9, you can mentally put a 3 in the top right box. With that clue, you can multiply 3 times 4, and give Tobbs a 12 for the box he's in.

X	(2)	(3)
4	8	
3	(6)	9

Figure 20b

In Level 4, the outside numbers are only 1, 2, 3, or 4. This means the inside numbers range from 1 to 16.

Level 5

Level 5 is the same as Level 4, except that the outside numbers range from 1 to 9. Here's a typical Level 5 puzzle and its solution:

X		
2	6	
5		20

Figure 21a

"Five times something is something. I don't know what that is, but I know what I multiply by 2 to get 6."

X	(3)	
2	6	
5		20

Figure 21b

So now you know that the original problem is 5 times 3.

X	(3)	
2	6	
5	15	20

Figure 21c

Try to complete the whole grid.

Here are some more Level 5 puzzles:

X		
5	30	40
4		

Figure 22

X		7
	20	28
		56

Figure 23

Level 6

Level 6 differs substantially from the other levels. The outside numbers range from 0 to 9, and for the first time, you have some choices, within limits, of what the answers might be. Look at this example:

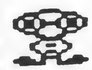
X	3	
	6	
	24	

Figure 24a

It's easy to find the left outside numbers:

X	3	
(2)	6	
(8)	24	

Figure 24b

But that doesn't help you find the number for the box you want. The solution is that the box can be 2 or 20 or 14 or <u>any number</u>, as long as the box is filled in with a multiple of 2 (an even number), and the number doesn't go outside its limit of whole numbers from 0 to 99. Try 14, as in the following example:

X	3	
(2)	6	14
(8)	24	

Figure 24c

Right! Once you choose 14, you can easily find an answer for the other open boxes. Here's the full solution:

X	3	7
2	6	14
8	24	56

Figure 24d

Of course, you didn't have to choose 14 for the original puzzle!

X	3	
	6	
	24	

Figure 24e

Suppose you'd chosen 30:

X	3	
	6	30
	24	

Figure 24f

This would force the system beyond whole numbers from 0 to 99 (because one product would be 120).

X	3	(15)
(2)	6	30
(8)	24	(12′

Figure 24g

What's the range of possible solutions to the original problem?

X	3	
	6	
	24	

Figure 24h

Here are some other Level 6 puzzles for you to solve. Try them. Don't be afraid of a trial-and-success method. And don't be afraid of asking other people to help out. Mathematics is more than just "drill and practice" or "what's the formula?" It's a mental construction; it's the creation of relationships. Knowledge is not a spectator sport!

X	2	1
	0	
		

Figure 25

X	0	
5		
8		

Figure 26

X	8	0
4	32	
0		0

Figure 27

Scoring

You earn one point for each correct answer. Each player has 4 to 6 squares to fill in. After you've tried all the puzzles, Tobbs tells you how many you answered correctly out of your tries.

Then he asks if you'd like to try another set at the same level. Type "YES" (or "Y") or "NO" (or "N") and press the RETURN key. If you answer yes, you have more teasers to fill in. If you answer no, he asks if you want another level. Scoring is cumulative as long as you stay on one level, but it starts over if you choose a new level.

Special keys

At any time, you can give the program special commands, as follows:

Type "P" to pass (that is, give up your turn). You lose a turn, and the second player gets a try at the same problem. This gives him an advantage of more chances to try for points. If you're playing a one-player game, there's no penalty, but Tobbs moves to another square.

Type "N" to get a new puzzle. You might want to ask for a new puzzle if the one on the screen isn't a challenge, or if it's too difficult. There's no penalty.

Type "H" to get help. In levels 1, 2, and 3, Tobbs draws lines to show what outside numbers to use in the computation. In levels 4 and 5, Tobbs hints at the answer. He suggests what he would put in the box. He's always right! In level 6, where more than one answer is possible, he suggests one possible correct answer.

At any time, you can hold down the control key (marked "CTRL" or "CONTROL") and type E to end the program. First, Tobbs repeats the summary of your score, and then he asks if you'd like to try another set at the same level. When you type "NO" or "N" and press the RETURN key, he asks if you'd like to try a new level. To end the game, type "NO" or "N" and press the RETURN key. The menu reappears. Select option 4, End, as described on page 4.

Note for parents and teachers

What's the role of the teacher or parent with this computer program? It's not just to pass information and facts along to children. It's to let children experiment, to put the burden of learning in their laps, and to make them thinkers rather than memory bins.

Teachers or parents, of course, should become familiar with the puzzles by playing at least two or three games at each level. Beyond that, they should act as midwives in the birth of ideas. That is, if a child comes up with a question, it's helpful to throw the question back with a bit of encouragement. Encouragement could be a statement of trust in the child's ability, and a suggestion that the child try a hunch--even a guess--and follow its consequences. Trial-and-error often turns into trial-and-success.

Another approach to children's questions is to team up partners who can work together. Whatever happens, it's best not to give them the answers.

Sometimes children come up with addition or multiplication procedures that aren't standard classroom technique. A helpful parent or teacher should encourage these creative procedures. For example, in adding 39 + 12, children might say that 40 + 12 is 52, and since 39 is one less than 40, then 39 + 12 = 52 - 1 or 51.

<u>Note</u>: There's one specific case in which teachers or parents should intervene. Players must know the format of the grid. Because they're familiar with vertical addition, some children may add 6 to 7 to fill in the box as in the following example:

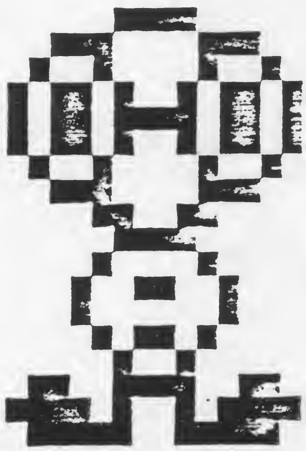
+	6	
	7	
	13	

Figure 28

In this case, the parent or teacher must interfere in a straightforward way, or the child won't make any progress.

Teachers and parents should also make sure the children know the mechanics of operating the program. For example, they should be able to type N for new grid, P for pass, H for help, and Control-E to stop.

Parents and teachers can take advantage of a feature of the four-player version at higher levels. The first player has the first turn each time a new puzzle grid appears. The first blank box is the hardest one to answer because there are more unknown numbers. Therefore it's a good idea to have the strongest player (or team) enter his name first to even the challenge.



Theoretical background

> Intellectual development is marked by increasing capacity to deal with several alternatives simultaneously, to tend to several sequences during the same period of time and to allocate time and attention in a manner appropriate to these multiple demands.
>
> --Jerome S. Bruner, Toward a Theory of Instruction, p. 6.

One of the chief complaints of teachers is that children return to school every September seeming to have forgotten much of what they've learned during the previous school year. "We teach 'em, but they don't stay taught," say teachers. (It's not only June to September that forgetting takes place; it's often day to day.)

One reason is that schools often fail to encourage the natural ability children have to organize and make sense of the world around them. Up to school age, children do an incredible amount of organizing. For example, without systematic instruction, they make sense of their natural language. Then when they come to school, adults organize things for them, and their only task is to store and remember when test time comes (and forget when tests are over).

The consequence is not only that children forget, but also that they cease to be thinkers and problem solvers and organizers, at least in their school subjects. It's commonplace to hear teachers say--about children as early as third grade--"They won't think; they only want me to give them the answer." Even at the university level, I've heard complaints, not just that students are unprepared in grammar, punctuation, and the so-called "basics", but that they won't think. They won't tackle an original problem, preferring to deal with problems for which they've stored a ready-made formula.

Sorry, folks. That's not how it should be. Present-day children will live most of their lives in the twenty-first century. Some of their children will be alive in the twenty-second century. We can't afford to prepare them with a nineteenth century education.

So what about Tobbs's puzzles? How do they fit in? Here are three ways:

(1) The puzzles provide drill and practice in addition or multiplication. The first three levels of the addition puzzles and the first two levels of the multiplication puzzles call for children to perform various computations and to report an answer. Using pencil and paper is O.K., but the puzzles are a great way to develop mental arithmetic skills.

For example, the puzzles ask children to compute 3 + 4 or 4 + 2. Math instruction ends here for many children in present-day schools. It's an important issue, of course, but computational accuracy and speed are a bit less important for children (and for society), now that they can buy calculators for $3.99, and now that computers can perform 100 million long multiplications in one second.

(2) Tobbs goes far beyond computation into reversibility. For example, in Level 4 of the addition puzzles, children have to work backward from sum to addends to solve problems like this:

+		4
1	3	5
3	5	7

Figure 29

They have to ask, "What do I add to 1 to get 3?"

In the multiplication puzzles, they face problems like the following:

X	4	
7	28	42
5	20	30

Figure 30

"What do I multiply by 7 to get 42?"

(3) At the higher levels of both addition and multiplication puzzles, children face one of the most important distinctions in mathematical thinking: the distinction between what must be, can be, and can't be. For example, in Figure 31, the answer must be 5. In Figure 32, the answer can be 5 (but it need not be; it could be 7 or even 99--the program deals only with numbers from 0 to 99). In Figure 33, the answer can't be 5. (Try it; you'll find that the rest of the puzzle grid goes awry.)

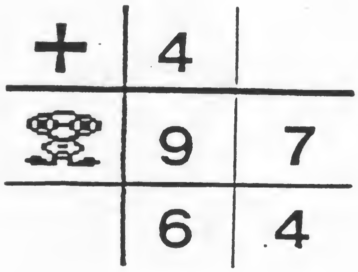


Figure 31

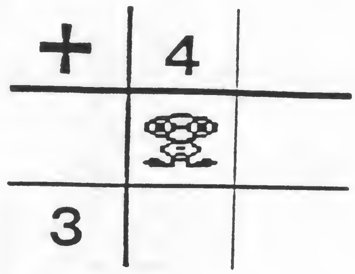


Figure 32

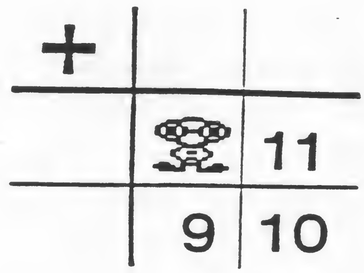


Figure 33

(4) There are other payoffs to Tobbs. For example, children learn to work within the constraints of a problem. In this puzzle, the box Tobbs is in can't be any old number, even though it looks like a free choice (from 0 to 99) at first.

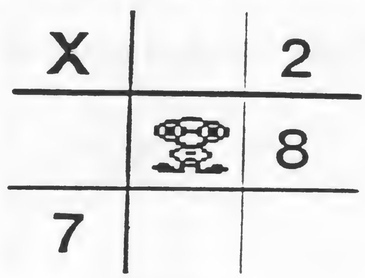


Figure 34

If you give Tobbs 5, he'll politely reject it. The program will, however, accept any multiple of 4, up through 96.

The puzzles also call for children to follow up the consequences of their ideas. Consider, for example, the following grid:

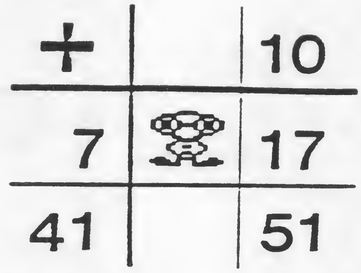


Figure 35a

It looks at first as if you can place any number up to 99 in the box where Tobbs is. Not so. Try 90:

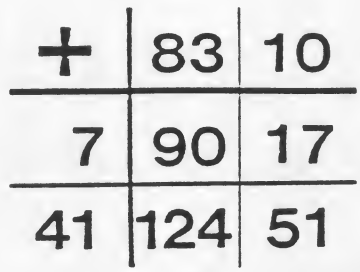


Figure 35b

Since 90 would force the program beyond its 0 to 99 limit, Tobbs rejects it politely.

Another decision players have to make is important in problem solving: "Where do I begin?" Consider this example:

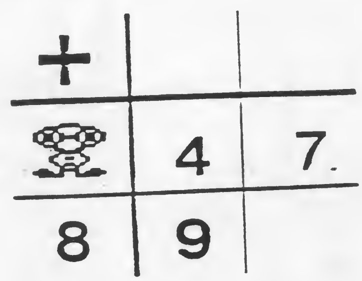


Figure 36a

You can't answer the question directly, but once you realize that the 8 and 9 force you to place a 1 in the top middle box, the rest is easy. Can you solve it?

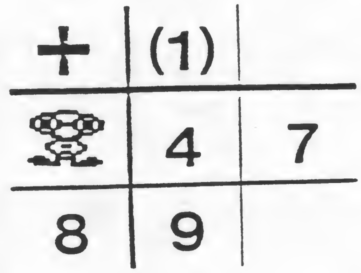


Figure 36b

In summary, children have to construct chains of thought when they're solving these problems. Perhaps this is the most important component of problem-solving ability.

Summary

So what do the puzzles do for children? In brief, the puzzles enable them to construct, organize, and make sense of addition and subtraction or multiplication and division relationships, and to learn problem-solving skills that will serve them throughout life. This is a fruitful--and a basic--activity!

In his prize-winning Godel, Escher, Bach: An Eternal Golden Braid, Douglas R. Hofstadter addresses the issue TEASERS BY TOBBS is most concerned with: the growth of intelligence.

> "[The] essential abilities for intelligence are certainly:
> to respond to situations very flexibly;
> to take advantage of fortuitous circumstances;
> to make sense out of ambiguous or contradictory messages;
> to recognize the importance of different elements of a situation;
> to find similarities between situations, despite differences which may separate them;
> to draw distinctions between situations which may link them;
> to synthesize new concepts by taking old concepts and putting them together in new ways;
> to come up with ideas that are novel."

The growth of intelligence, particularly mathematical intelligence, is what Tobbs is all about!

About the author

Thomas C. O'Brien is professor and director of the Teachers' Center Project at Southern Illinois University, Edwardsville, Illinois. As a teacher, he has worked with students from seventh grade through graduate school. As a curriculum developer, he's author of twelve problem books for children. Through a Teacher's Center Project, he has written or edited some eighty papers on children's thinking and education.

As a researcher, he has studied the growth of mathematical ideas in subjects from preschool through medical school and law school. He has also published and delivered some one hundred papers in children's thinking, mathematics education, intellectual development, and educational change in the United States, Holland, France, Switzerland, Hungary and Brazil. In 1978, he was a North Atlantic Treaty Organization Senior Research Fellow-in-Science.

He earned his bachelor's degree from Iona College, New Rochelle, N.Y., and his Ph.D. from New York University.

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2. If you have problems using the program, please describe them here.

3. What do you especially like about this program?

4. What do you think the program's weaknesses are?

5. How can the catalog description be more accurate or comprehensive?

6. On a scale of 1 to 10, 1 being "poor" and 10 being "excellent", please rate the following aspects of this program:

_______ Easy to use
_______ User-oriented (e.g., menus, prompts, clear language)
_______ Enjoyable
_______ Self-instructive
_______ Useful (non-game programs)
_______ Imaginative graphics and sound

7. Describe any technical errors you found in the user instructions (please give page numbers).

8. What did you especially like about the user instructions?

9. What revisions or additions would improve these instructions?

10. On a scale of 1 to 10, 1 representing "poor" and 10 representing "excellent", how would you rate the user instructions and why?

11. Other comments about the program or user instructions:

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Teasers by Tobbs: Puzzles and Problem Solving

Teacher's Guide

SUNBURST
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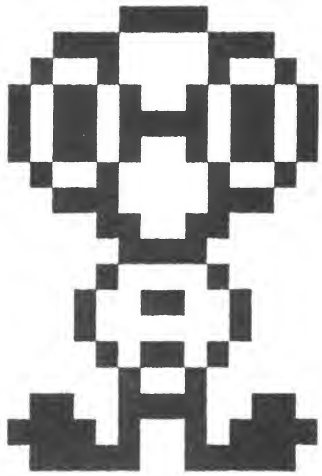
Author: Thomas C. O'Brien

Editor: Marge Kosel

Programmers: Cathy McMahon
Jay Carlson
Walter Koetke III
Todd Bailey
Jim Brayton
Jon Sweedler



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About the Author:

Thomas C. O'Brien is professor and director of the Teachers' Center Project at Southern Illinois University, Edwardsville, Illinois. His work in education is three-fold: teacher education, curriculum development, and research on children's thinking. As researcher, he has studied the growth of mathematical ideas in subjects from pre-school to medical school and law school. As teacher, he has worked with children from grade 7 through graduate school. As curriculum developer, he is author of twelve problem books for children, as well as author and editor of some eighty papers on children's thinking and education, published through the Teachers' Center Project.

In addition, Dr. O'Brien has published and delivered some 100 papers in children's thinking, mathematics education, intellectual development and educational change. His papers and presentations have taken place in the USA, Canada, Great Britain, Holland, France, Switzerland, Hungary and Brazil. Dr. O'Brien was named a North Atlantic Treaty Organization (NATO) Senior Research Fellow-in-Science in 1978. Dr. O'Brien received has bachelor's degree from Iona College, New Rochelle, NY, and his Ph.D. from New York University.

Many Thanks:

Many people helped to get this work to its present state and I am pleased to say Thank You to them.

Thomas C. O'Brien III taught me that a computer is not full of dragons. Liza Loop helped to get this project from a mere idea to a pilot product. Bill Maintz contributed great goodwill, encouragement and thoughtful advice. Jeff Van Arsdale taught me not to do stupid things at the keyboard. Many local teachers--Z. Miller, Mary Steffen, Shirley Casey, especially--and their school children helped greatly with informed and constructive criticism.

Marge Kosel and Cathy McMahon brought great insight, care, and expertise to the final product.

And my family gave patient support from Dog Days to Triumphant Tryouts as the present work grew in maturity and complexity.

To all of you, my warmest thanks.

Thomas C. O'Brien

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INTRODUCTION
by Thomas C. O'Brien

> Intellectual development is marked by increasing capacity to deal with several alternatives simultaneously, to tend to several sequences during the same period of time and to allocate time and attention in a manner appropriate to these multiple demands. -- Jerome S. Bruner, Toward a Theory of Instruction, p. 6.

One of the chief complaints of teachers is that children return to school every September seeming to have forgotten much of what they've learned during the previous school year. "We teach 'em but they don't stay taught," say teachers. (It's not only June to September that forgetting takes place; it's often day to day.)

One major reason for such a situation is that schools often fail to capitalize on and to encourage the natural ability children have to organize and to make sense of the world that surrounds them. Up until school age, children do an incredible amount of organizing. For example, children are able, without systematic instruction, to make sense out of their natural language. Then when children come to school, adults organize things for them and their only task is to store and remember when test time comes. (And then forget when tests are over.)

The consequence of such a practice is not only that children forget from June to September and from day to day, but that they cease to be thinkers and problem solvers and organizers, at least so far as school subjects are concerned. It's far too commonplace to hear teachers say--about children as early as third grade--"They won't think, they only want me to give them the answer." Indeed, at the university level, the chief complaint I've heard is not that students are unprepared in grammar and punctuation, etc. (the so-called "basics") but that university students won't think. They won't tackle an original problem and want only to deal with problems for which they've stored a ready-made formula.

Sorry, folks. That's not how it should be. Present day children will live most of their lives in the Twenty-First Century. Some of their children will be alive in the Twenty-Second Century. We cannot afford to prepare them with a Nineteenth Century education.

So what about the puzzles involving Tobbs? How do they fit in? There are three aspects to the puzzle:

(1) The puzzles provide drill and practice in addition or multiplication. The first three levels of the Addition Puzzles and the first two levels of the Multiplication Puzzles call for children to perform various computations (pencil and paper is OK) and to report an answer. Without pencil and paper, the puzzles provide a superb arena for the development of mental arithmetic skills.

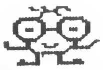
For example, children are asked to compute 3 + 4 or 4 x 2. This is where math instruction often ends for many children in present day schools. It's an important issue, of course, but computational accuracy and speed are a bit less important for children (and for society) now that calculators can be purchased for as little as $3.99 and computers can perform as many as 100 million long multiplications in one second.

(2) Tobbs goes far beyond computation into reversibility. For example, in Level 4 of the Addition Puzzles, children are asked to work backward to solve problems like this:

+		4
1	3	5
3	5	7

What do I add to 1 to get 3?

And in the multiplication puzzles, they are faced with:

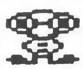
X	4	
7	28	42
5	20	30

What do I multiply by 7 to get 42?

(3) Further, at the higher levels in both the addition and multiplication puzzles, children face one of the most important distinctions in all of mathematical thinking: the distinction between must be, can be, and can't be. For example, in problem 1, the answer must be 5. In problem 2, the answer can be 5 (but it need not be; it could be 7 or even 99--the computer is programmed to deal only with numbers from 0 to 99). And in problem 3, the answer can't be 5. (Try it; you'll find that the rest of the puzzle grid goes awry.)

+	4	
	9	7
	6	4

(1)

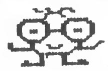
+	4	
		
3		

(2)

+		
		11
	9	10

(3)

(4) There are other payoffs to Tobbs, only a few of which we'll mention here. For example, children learn to work within the constraints of a problem. In this puzzle, the box that Tobbs is in cannot be any old number, even though it looks like a free choice (from 0 to 99) at first.

X		2
		8
7		

If 5 is given to the computer as an answer, it will be politely rejected. The machine, however, will accept any multiple of 4 up to 99.

And the puzzles call for children to follow up the consequences of their ideas. For example, in

+		10
7		17
41		51

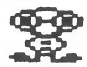
it looks as though any number up to 99 can be placed in the box where Tobbs is. Not so. Try 90:

+	83	10
7	90	17
41	124	51

The consequences of the 90 are that the computer is forced beyond its 0 to 99 limits and so 90 is politely rejected.

Further, the puzzles call for children to make one of the most important decisions in problem solving: "Where do I begin?" What's the

starting point here?

+		
	4	7
8	9	

One cannot answer the question directly. But once it's realized that the 8 and 9 force a 1, the problem is easy. Can you solve it?

+	(1)	
	4	7
8	9	

In solving the puzzles, children have to construct chains of thought, another important component of problem-solving ability.

SUMMARY

So what do the puzzles do for children? In brief, the puzzles enable them to construct, organize and make sense out of addition and subtraction or multiplication and division relationships and to learn problem- solving skills which will serve them throughout life. A fruitful activity this is. A basic activity!!!

When I was charged with the responsibility of preparing these pages, it was mentioned that readers might be used to behavioral objectives and that I should take care to make clear what the payoffs of Tobbs' Puzzles would be for children. I have tried to do so above but I have tried to write so that the reader would be a participant and not a passive storer of a Tobbs laundry list. In his prize winning *Godel, Escher, Bach: An Eternal Golden Braid*, Douglas R. Hofstadter addresses the issue with which Teasers by Tobbs are most intimately concerned: the growth of intelligence.

> "[The] essential abilities for intelligence are certainly:
> to respond to situations very flexibly;
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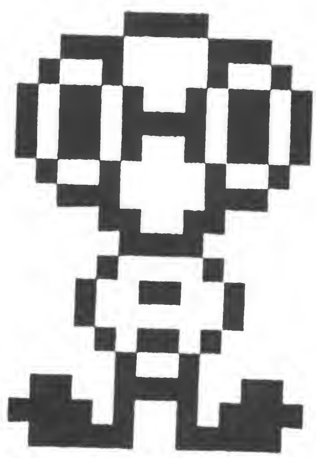


THE ROLE OF THE TEACHER

What's the role of the teacher with this computer material? Commonly, the role of the teacher is to pass information and facts along to the pupils. That's NOT the situation here.

The role of the teacher is to let children experiment, to put the burden of learning in their laps, and to make them thinkers rather than memory bins.

Teachers, of course, should get familiar with the puzzles by playing with them--two or three games at each level. Beyond that, the major role of the teacher is to act as a midwife in the birth of ideas. That is, if a child comes up with a question, throw the question back with a bit of encouragement, a statement of trust in the child's ability, and a suggestion that the child try a hunch (or if no hunch, make a guess) and follow out the consequences of the hunch/guess. Trial and error very often turns into trial and success.

A second approach to children's questions is to team the questioner with a partner (or encourage them to choose a partner) and let them work together to figure things out. Whatever happens, try not to give answers to children. Knowledge is not a spectator sport.

Encourage children to come up with addition or multiplication procedures that may not be taught as a standard classroom technique. For example: adding 39 + 12, children should see that 40 + 12 is 52 and since 39 is one less than 40 then 39 + 12 = 52 - 1 or 51.

There is one specific thing that teachers can do. It is obviously essential that players know the format of the grid. Because they are familiar with vertical addition, some children may add 6 and 7 to fill the box in a situation such as this:

+	6	
	7	
	13	

This situation requires straightforward teacher intervention, lest children make no progress at all. When such a situation occurs, swing the players back through the program instructions and make sure the format is clear to them. Also, the teacher should help the child with the mechanics of operation. Students should be taught how to operate the machine, the features of the program--N for New Grid, P for Pass, H for Help, Control E to stop, and how to End and turn off the machine.

BACKGROUND ON PLAYING

Children can play the puzzle solo or in groups. If they play in groups, they can play cooperatively by giving the machine a single name for the group, or they can play competitively. A score is kept as the number correct out of the number of tries. At the end, the player's names are printed in order from the highest score to the lowest. The students are then asked if they would like another set at the same level. If NO, the student is asked if they would like to try a new level. If YES, the same players are involved in another level.

The computer is programmed to deal only with whole numbers from 0 to 99. Anything which causes it to go beyond these limits will cause the computer to give a message to that fact. Decimals are not allowed.

At any point, players can press:

P to pass. The player will lose a turn and give the second player an advantage. If playing with a single player, there is no penalty.

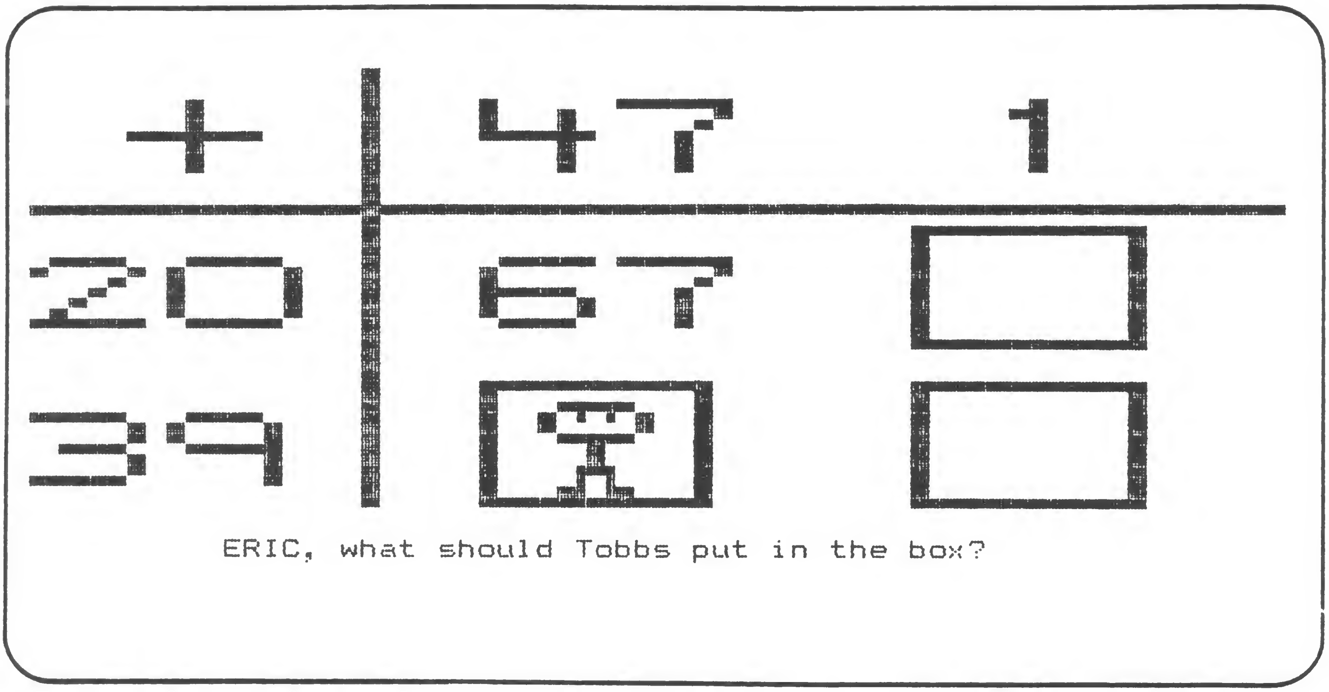
N to get a new puzzle. If the puzzle is not a challenge or if it is too difficult, students can call for a new puzzle. No penalty is accessed. If the players want to end, they must use the Control E option.

H to get help. In levels 1 - 3, Tobbs will draw lines that will indicate what numbers are involved in the computation. In levels 4 and 5, Tobbs will give the students the answer. In level 6, where more than one answer will work, Tobbs will give one answer but not fill in the box. Students are encouraged to with this clue, to find a different answer.

Control E - hold the Control key and press E at any input to end the program. Choose the End option on the menu. On the TRS-80, hold the Shift Key and down arrow key while pressing the E key. After the summary score is printed, if the student would like to use a new diskette or start this diskette over, they should answer YES to the question on using a new diskette.

Students are given 4 or 5 problems per game. If there are two players, eight to ten blanks will appear before the game is over.

ADDITION PUZZLES



Skills:	Addition and subtraction of one-digit numbers. Addition and subtraction of two-digit numbers.
Students Work With:	Addition Logic
Grade Level:	3 - 12
Reading Level:	3rd grade (Spache)
Time Required:	5 - 10 minutes

Background on Addition Puzzles

The Addition program has six levels of difficulty and can be played by 1 - 4 players. The levels vary in the difficulty of the problems and the difficulty of the logic involved.

Level 1 offers children mental arithmetic drill and practice in addition with addends from 0 to 9. Only one inside unknown is called for. As with all the puzzles, a player can press P for pass, N for new grid, H for help, of Control E for end. As with all the puzzles, a player gets one point for a correct answer and receives no points for an incorrect answer. Here are some possible Level 1 puzzles:

+	8	5
4	12	
0	8	5

+	6	5
5	11	10
9	15	

Level 2 is the same as Level 1, except that up to four inside unknowns can occur. The puzzle formats are chosen at random by the computer. Here are some Level 2 grids:

+	8	7
9	17	
6	14	

+	8	3
5		8
8	16	

Level 3 is the same as Level 2, but this time the addends range from 0 to 48. The use of pencil and paper to reach an answer is by all means acceptable but children are almost certain (if allowed/encouraged) to come up with some very rich addition procedures such as, "17 + 35 is 52 because 20 + 35 is 55 and 17 is 3 less than 20." Here are some grids from Level 3:

+	37	20
21		
39		

+	35	7
21		
39		

In Level 4, children meet puzzles which call for them to work backwards and thus must subtract. For example, in

+	4	7
3	7	10
	5	8

the question is "What do you add to 4 to get 5?" (Or "What do you add to 7 to get 8"?)

Also in Level 4, children have to make decisions as to where to enter a puzzle. Having decided where to start, they sometimes have to construct complex strings of thought. For example, here is a Level 4 puzzle:

+		
5	7	
9		10

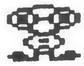
At first glance, there is no answer. "I add 5 to something to get something. H-E-L-P." The fact is that there is additional information lying around. Using the information in the given grid, one can mentally figure out this much:

+	(2)	(1)
5	7	
9	(11)	10

And so the answer to the designated box is 6.

In Level 4, the possible outside numbers range from 0 to 9 (thus, the inside numbers must fall in the range 0 to 18).

Level 5 is the same as Level 4, except that the outside numbers range from 0 to 49. Here is a typical Level 5 puzzle and its solution:

+		
3	5	
17		42

"17 plus something is something. I don't know what to do. I do know what to add to 3 to get 5."

+	(2)	
3	5	
17		42

So I know that my original problem, though I didn't see it at the start, is 17 + 2.

+	(2)	
3	5	
17	19	42

Can you complete the entire grid?

Level 6 differs substantially from Levels 1-5. Here the range of outside numbers is 0 to 48, as in Level 5, but for the first time one has a free choice (within limits) as to the answer. For example:

+	3	
	7	
	29	

Obviously, the left outside numbers are determined:

+	3	
(4)	7	
(26)	29	

But that's no help whatsoever so far as the designated box is concerned. The solution is that the box can be 7 or 35 or 50 or any number, so long as the puzzle is not pushed beyond its limits of whole numbers from 0 to 99. Let's try 40:

+	3	
(4)	7	40
(26)	9	

Right!

Now all the open boxes are determined. Here is the full solution:

+	3	36
4	7	40
26	29	62

Of course, 40 need not have been chosen for the original puzzle. Here's another example:

+	3	
	7	
	29	

Suppose one had chosen 2:

+	3	
	7	2
	29	

Such a choice would force the system beyond whole numbers for 0 to 99.

+	3	-2
4	7	2
26	29	

Ooops!

Would anything from 4 to 99 have been OK? Here's 97:

+	3	
	7	97
	29	

+	3	93
4	7	97
26	29	119

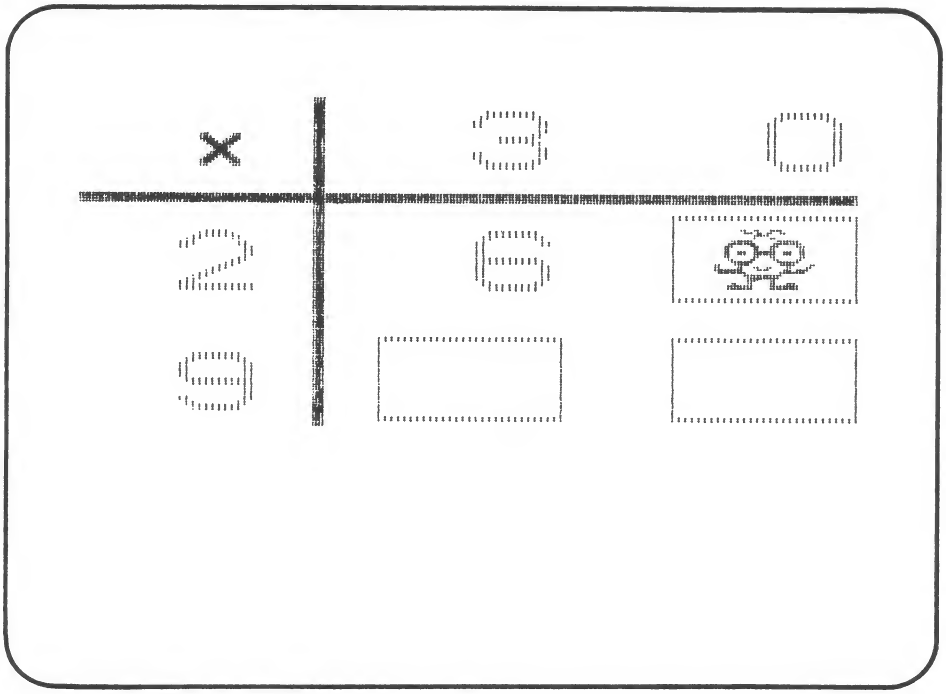
Ooops!

97 would not have been correct because it forced a number beyond the 0 to 99 range. The solution to the original problem is any whole number from 4 to 77. The 77 forces the following situation:

+	3	73
4	7	77
26	29	99

which stretches the system to its 0 to 99 limits.

MULTIPLICATION PUZZLES



Skills:	Multiplication and division of one-digit numbers. Multiplication and division of two-digit numbers.
Students Work With:	Multiplication Logic
Grade Level:	4 - 12
Reading Level:	3rd grade (Spache)
Time Required:	5 - 10 minutes

Background on Multiplication Puzzles

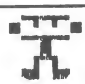
Multiplication, also, has six levels of difficulty and can be played by 1 - 4 players. The levels vary in the difficulty of the problems and the difficulty of the logic involved.

Level 1 offers children mental arithmetic drill and practice in multiplication with factors from 0 to 4. Only one inside unknown is called for. As with all the puzzles, a player can press P for pass, N for a new grid, H for help, or Control E to end. As with all the puzzles, a player gets one point for a correct answer. Here are some possible Level 1 puzzles:

X	2	1
4	8	
0	0	0

X	1	4
2	2	8
3	3	

Level 2 is the same as Level 1, except that up to four inside unknowns can occur. The puzzle formats are chosen at random by the computer. Here are some Level 2 grids:

X	1	0
4	4	
1		

X	3	2
4		
2		

Level 3 is the same as Level 2, but this time the factors range from 0 to 9:

X	7	5
1		5
8		

X	3	2
5		
0		

In <u>Level 4,</u> children meet puzzles which call for them to work backwards. For example, in

X	4	1
3	12	3
	8	2

the question is "What do you multiply by 4 to get 8?" (Or "What do you multiply by 1 to get 2?")

Also in Level 4, children have to make decisions as to where to enter a puzzle. Having decided where to start, they sometimes have to construct complex strings of thought. For example, here is a Level 4 puzzle:

X		
4	8	
3		9

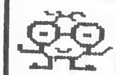
At first glance, there is no answer. But, there is additional information lying around. Using the information in the given grid, one can mentally figure out this much:

X	(2)	(3)
	8	
3	(6)	9

And so the designated box is 12.

In Level 4, the possible outside numbers range from 1 to 4 (thus the inside numbers must fall in the range 1 to 16).

Level 5 is the same as Level 4, except that the outside numbers range from 1 to 9. Here is a typical Level 5 puzzle and its solution:

X		
2	6	
5		20

"5 multiplied by something is something. I don't know what to do. I do know what I multiply 2 by to get 6."

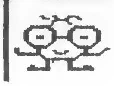
X	(3)	
2	6	
5		20

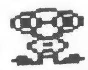
So I know that my original problem, though I didn't see it at the start, is 5 x 3.

X	(3)	
2	6	
5	15	20

Can you complete the entire grid?

Here are some typical Level 5 puzzles:

X		
5	30	40
4		8

X		7
	20	28
		56

Level 6 differs substantially from Levels 1-5. Here the range of outside numbers is 0 to 9 and, for the first time, one has a free choice (within limits) as to the answer. For example:

X	3	
	6	
	24	

Obviously, the left outside numbers are determined:

X	3	
(2)	6	
(8)	24	

But that's no help whatsoever so far as the designated box is concerned. The solution is that the box can be 2 or 20 or 14 or any number so long as the box is filled in with a multiple of 2 and the puzzle is not pushed beyond its limits of whole numbers from 0 to 99. Let's try 14:

X	3	
(2)	6	14
(8)	24	

Right!

Once 14 is chosen, all the open boxes are determined. Here is the full solution:

X	3	(7)
	6	14
(8)	4	(56)

Of course, 14 need not have been chosen for the original puzzle:

X	3	
	6	
	24	

Suppose one had chosen 30:

X	3	
	6	30
	24	

Such a choice would force the system beyond whole numbers for 0 to 99.

X	3	(15)
(2)	6	30
(8)	24	(120)

What is the range of possible solutions to the original problem?

X	3	
	6	
	24	

Here are some other Level 6 puzzles for you to solve. Try them. Don't be afraid of a trial-and-success approach. And don't be afraid of asking colleagues to pitch in. Mathematics has long been thought of as "Drill and Practice" or as "What's the formula?" It's NOT. It's a construction of the mind. It's the creation of relationships. Knowledge is NOT a spectator sport!!!

X	2	1
	0	
		

X	0	
5		
8		

X	8	0
4	32	
0		0

<u>APPLE II PLUS: WORKING WITH THE COMPUTER</u>

1. Turn on the television or monitor.

2. Insert the diskette into the disk drive with the label facing up and on the right.

3. Close the door to the disk drive.

4. Turn on the Apple II. (The on-off switch is on the back left side of the computer.)

5. You will see a red light on the disk drive turn on. If the disk drive light does not turn off in about 10 seconds, turn the Apple off and make sure your diskette is placed correctly in the disk drive.

6. SUNBURST will appear on the screen with the diskette name.

7. Follow directions given in the program.

<u>Shutting Off the System</u>

1. Remove the diskette from the disk drive and return it to its place of storage.

2. Turn off the Apple.

3. Turn off the television or monitor.

ATARI: WORKING WITH THE COMPUTER

TURNING ON THE COMPUTER:

1. Turn on the television or monitor.

2. The disk drive must be turned on before the computer. Turn on the disk drive using the switch on the front. Two lights will come on, the "PWR ON" light and the disk "BUSY" light. After about 10 seconds, the BUSY light should go off.

3. Press the rectangular release button below the disk drive door and the door will open. Insert a diskette with the exposed oval "window" inserted first and the label side up.

4. Close the door on the disk drive.

5. A menu will appear with a list of available programs. Select the program you want and press the RETURN key.

6. Follow the instructions in the program.

TURNING OFF THE COMPUTER:

1. Remove the diskette.

2. Turn off the disk drive, television and the Atari.

TRS-80: WORKING WITH THE COMPUTER

1. Turn on the video display if it is separate from the computer.

2. Turn on the computer. If your TRS-80 has a disk drive, hold the BREAK key down while you turn on the computer. If you have a TRS-80 Model III, type L and press ENTER when the computer ask "CASS?".

3. Choose the tape you wish to use.

4. Insert the tape in the tape recorder (the label of the program you want should be facing up).

5. Make sure the tape is rewound.

6. Press the PLAY button on the tape recorder.

7. Type CLOAD and press the ENTER key. (This starts the tape recorder.)

8. Two stars (**) will appear and blink on the top line of the screen. This indicates the program is loading.

   If you don't see the two stars (one star should be blinking) in the upper right-hand corner in about 30 seconds --

   - reset the computer (see How to Reset the Computer);
   - check the volume control (it should be set between 6 and 8);
   - make sure all the plugs are in place; and
   - try again, starting at Step 4.

9. When READY appears on the screen, press REWIND. Return the tape to its box. The program is now loaded into the computer's memory.

10. Type RUN and press ENTER.

11. Follow the instructions that appear on the screen.

How to Reset the Computer

When you press the RESET button, it resets the computer without erasing the memory. With the Model I (separate keyborad and monitor), the RESET button is located at the left rear of the keyboard (inside of a small door).

The Model III is reset by the BREAK key (on the keyboard). When you reset the computer, the word READY will appear on the screen. You are now back in control and can run the program again. Type RUN and press ENTER, or load a new program from tape.

Shutting off the System

1. Turn off the video display if it is separate from the computer.

2. Turn off the computer.

"WHAT HAPPENS IF...?" -- SUNBURST COURSEWARE AND WARRANTY

1. What happens if a program will not load or run?
   Call us on our toll-free number and we will send you a new tape or diskette.

2. What if I find an error in the program?
   We have thoroughly tested the programs that SUNBURST carries so we hope this does not happen. But if you find an error, please note what you did before the error occurred. Also, if a message appears on the screen, please write the message down. Then fill out the evaluation form or call us with the information. We will correct the error and send you a new tape or diskette.

3. What happens if the courseware is accidentally destroyed?
   SUNBURST has a lifetime guarantee on its courseware. Send us the product that was damaged and we will send you a new one.

4. How do I stop a program in the middle to go on to something new?
   These programs can be ended at only time by holding the Control button and pressing the E Key. To change diskettes, select the End option on the menu and insert a new diskette.

5. Can I copy this diskette?
   The material on the diskette or cassette is copyrighted. You <u>should not</u> copy the courseware.